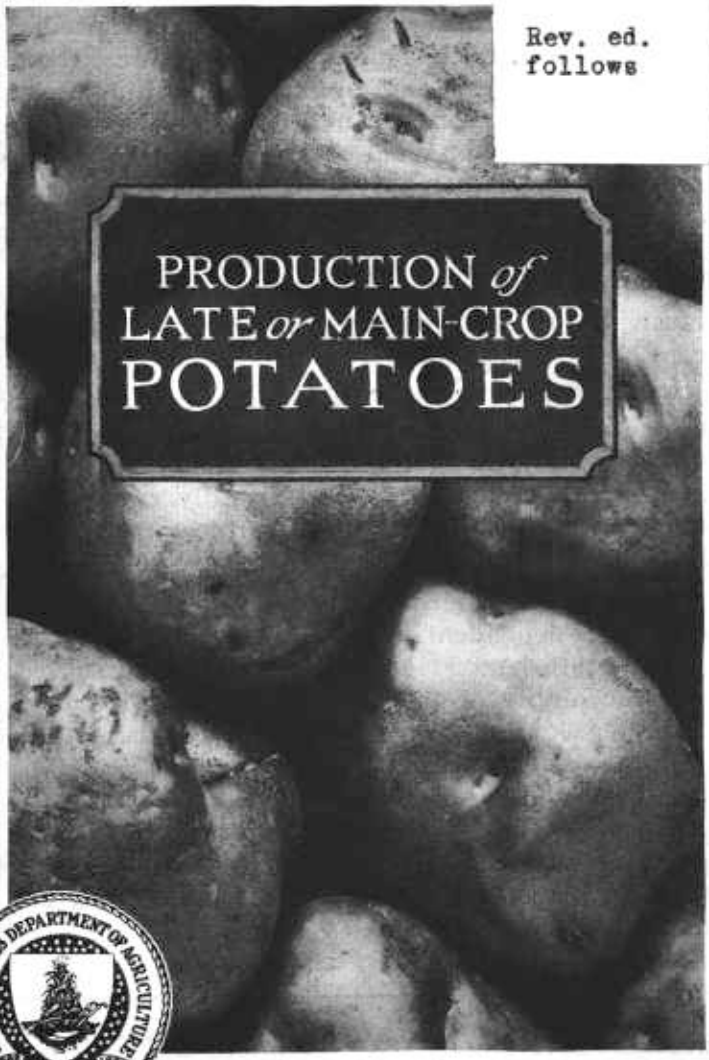
Pm 4605 - Dr. Stuart

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1064

d. rev. Apr. 1933

Rev. ed. follows



PRODUCTION of LATE or MAIN-CROP POTATOES

THE IMPORTANCE of the potato for table use is not generally realized by the consumer. The potato stands second only to wheat as a human food.

The potato industry resolves itself into the production of an early or truck crop and a late or main crop. The early crop goes into immediate consumption as soon as harvested, while normally only about one-third of the late or main crop is moved to the consuming centers when harvested, the remainder being stored as a reserve supply for winter and spring use.

The early or truck crop is grown in the South, and the late or main crop is produced almost exclusively in the North and constitutes about 85 per cent of the total potato crop of the country.

The essentials for the production of a maximum crop of potatoes are good soil properly prepared, an ample supply of available plant food, high-grade seed of a suitable variety used liberally, careful tillage, and thorough spraying to protect the foliage from insect and fungous enemies.

A maximum return from the crop after its production is dependent upon the care with which the potatoes are harvested, stored, graded, and sacked, and the ability of the grower to sell at the most advantageous time and in the best markets.

The information contained in this bulletin is primarily intended for the potato growers of the northeastern United States. Information relative to potato growing in the far western States is contained in Farmers' Bulletin 1639, Potato Production in the Far Western States.

Washington, D. C.

Issued September, 1919
Revised November, 1931
Slightly revised April, 1933

PRODUCTION OF LATE OR MAIN-CROP POTATOES

By WILLIAM STUART, *Senior Horticulturist, Division of Horticultural Crops and Diseases, Bureau of Plant Industry*

CONTENTS

IMPORTANCE OF THE CROP

LATE OR MAIN-CROP potatoes comprise about 85 per cent of the total potato crop of the country, which is divided into the early or truck crop, confined to the South, and the later or main crop grown very largely in the North. Production of the late or main crop is, therefore, correspondingly more important than that of the early crop.

THE POTATO A NORTHERN CROP

Though the production of late-crop potatoes is not wholly confined to the North, it is in reality very largely restricted to the northern tier of States. This is by no means an accidental circumstance, as it is a well-recognized fact that the potato does best in regions where the summer temperatures are relatively low and where irrigation water is available or the annual rainfall is ample and reasonably well distributed throughout the growing period. Such climatic conditions prevail to a large extent in the northeastern portion of the United States and in some of the more elevated portions of the West. Latitude and altitude, to a considerable degree, govern potato growing in the North and West. Location coupled with suitable climatic conditions determines the extent of the crop in any given State. Thus, the principal potato-producing States are New York, Minnesota, Wisconsin, Michigan, Maine, and Pennsylvania. These six States during the years 1921 to 1925 produced 193,824,600 bushels out of an average production for the entire country of 395,937,200 bushels, or over 48.9 per cent of the total crop. In the 5-year period 1926 to 1930, the same States averaged 173,590,000 bushels, or nearly 45.1 per cent of

the total crop and 54.3 per cent of the late crop. The relative production of these six States is graphically represented in Figure 1, in which the two 5-year periods are compared.

It would be misleading, of course, to assume that because Maine, New York, Pennsylvania, Michigan, Wisconsin, and Minnesota produced approximately 54.3 per cent of the total crop in the 32 late-potato-producing States, they are necessarily better adapted to potatoes than Colorado, Idaho, or any of the other group of Northern States. The real reason is that they are better located with respect to the large consuming centers of the United States.

This statement is amply substantiated by the data presented in Table 1, which gives the average rank and production per acre for the two 5-year periods.

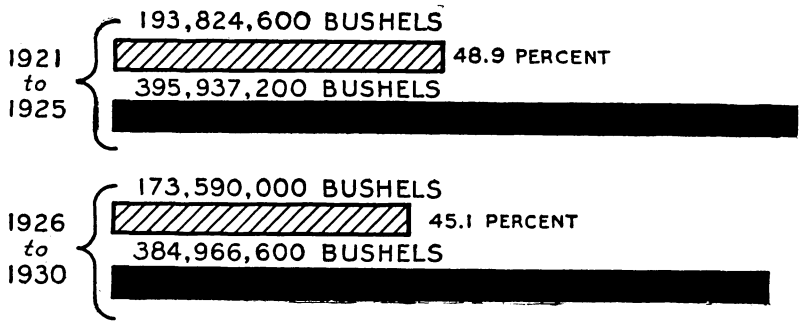


FIG. 1.—Diagram showing the comparative production of potatoes in the six principal potato-producing States and in the entire United States for the two 5-year periods, 1921 to 1925 and 1926 to 1930

TABLE 1.—*Comparison of the rank and acre production of potatoes in the Northern and far Western States, 1921 to 1925 and 1926 to 1930* [1]

State	Rank		Average acre yields		State	Rank		Average acre yields	
	1921 to 1925	1926 to 1930	1921 to 1925	1926 to 1930		1921 to 1925	1926 to 1930	1921 to 1925	1926 to 1930
			Bushels	*Bushels*				*Bushels*	*Bushels*
Maine	1	1	262.2	252.4	Michigan	17	27	106.6	90.0
Idaho	2	2	183.2	188.4	Wyoming	18	14	106.6	122.6
Nevada	3	8	174.2	151.0	Wisconsin	19	19	106.0	98.2
Utah	4	13	168.4	137.8	Minnesota	20	24	99.2	93.2
New Hampshire	5	3	153.0	166.8	Oregon	21	15	98.0	116.0
Vermont	6	4	151.0	160.4	Ohio	22	20	97.8	97.2
California	7	7	147.0	153.4	Iowa	23	23	86.2	93.8
Washington	8	6	146.0	155.2	North Dakota	24	29	86.2	80.4
Colorado	9	9	140.0	145.4	Indiana	25	26	82.8	91.4
Massachusetts	10	12	135.0	139.2	Nebraska	26	21	81.2	94.4
Connecticut	11	10	133.6	142.8	Illinois	27	28	75.6	86.4
Rhode Island	12	11	130.0	139.4	Kansas	28	18	75.2	108.8
New Jersey	13	5	123.8	155.8	South Dakota	29	31	74.8	76.8
New York	14	17	112.4	109.0	Missouri	30	25	74.6	91.6
Montana	15	22	109.4	94.2	Arizona	31	32	74.2	73.8
Pennsylvania	16	16	108.0	114.2	New Mexico	32	30	55.4	77.0

[1] The data from which the above table was prepared were obtained from the yearbooks of the U. S. Department of Agriculture except in the case of the 1930 data which were taken from the Bureau of Agricultural Economics, Aug. 18, 1931, crop prospect report on the potato and sweetpotato.

The striking variation in rank based on acre production of a few of the States affords convincing evidence of the influence of unfavorable climatic conditions on the potato crop.

LATE-POTATO PRODUCTION CENTERS

It would be somewhat difficult to name the distinctively potato-producing centers within the six States which have been classified as those producing large quantities of the late or main crop potatoes, and such production is by no means limited to these six States. The only well-recognized sections at the present time are Aroostook County, Me.; western New York; and the Red River Valley in Minnesota. Pennsylvania has no distinctively commercial center; neither has Michigan nor Wisconsin. A few years ago it might have been said of Wisconsin that the central portion of the State, comprising Portage, Waupaca, and Waushara Counties, was the strictly commercial section, but within the last few years the center of production has been moving northward until at the present time there does not appear to be any outstanding potato-producing district. Outside of these six States the following potato-growing districts are generally recognized: The Louisville district in Kentucky; the great American bottoms, in the vicinity of St. Louis; the Kansas (Kaw) River Valley in Kansas; the Greeley, San Luis Valley, Carbondale, and Montrose districts in Colorado; the Idaho Falls and Caldwell districts in Idaho; the Yakima Valley in Washington; and the delta sections of the San Joaquin and Sacramento Rivers near Stockton, Calif. In mentioning the above districts it is realized that there are many other localities which are of equal or greater importance than those specified, but no distinctive name has been given to them.

SOIL REQUIREMENTS

The potato is probably as cosmopolitan in its soil requirements as any of our crops and is widely grown throughout the United States; nevertheless it succeeds much better on certain soils than on others. This is well shown by the behavior of potatoes on the Caribou loam soil in Aroostook County, Me., as compared with the Washburn loam soil of the same district.

The Caribou loam soil is described by the Bureau of Soils as a hazel-brown silty loam with a plenteous admixture of small fragments of decomposing rocks which have been disintegrated by the flow of water or by the action of frost from the calcareous shale rock beneath. It was originally covered with hardwood timber, such as maple, oak, and beech.

Typical Washburn loam soil is black in color and generally occurs in the lower portions or depressions in the field. This type of soil was originally covered with soft woods, such as cedar, pine, and spruce. It is deficient in potash and seems to be very generally infested with the organisms of common scab. Where of equal fertility, larger and better crops of potatoes are always obtained from the Caribou loam type of soil; in fact, if the Washburn loam soil were segregated instead of being interspersed with the Caribou loam it is doubtful whether any grower would attempt to produce potatoes on it.

Many similar comparisons might be made between other types of soil occurring in the potato-producing areas of the North and West.

Certain types of soil are preeminently suited to the production of potatoes provided the necessary fertility is maintained. Generally speaking, potatoes succeed best on a gravelly or sandy loam soil which is naturally well supplied with moisture. Loose shifting sand and heavy clay loam or gumbo soils are unsuited to the crop, as are also thin soils underlain with a cold impervious subsoil.

CROP ROTATION

The crops which may be grown in rotation with potatoes in the region under discussion afford considerable latitude in the establishment of a definite rotation. In the strictly northern areas, as, for example, the New England States and the northern portions of New York, Michigan, Wisconsin, Iowa, and Minnesota, a 3 to 5 year rotation is generally practiced, in which the clovers play an important rôle. In a 3-year rotation a grain crop follows the potato crop, clover and grass seed being sown with the grain. The next year the first cutting of clover is made into hay, while the second growth is turned under in the late summer or early autumn in order to insure the decomposition of the sod and to expose the upturned soil to the action of the elements during the winter. When a longer rotation is practiced, it usually involves the retention of the land for hay production for one or two years, or the land may be pastured for a year or two. Occasionally a grower is found who prefers to follow the grass crop with corn and the next year with potatoes.

Where alfalfa is grown, it is desirable to practice a longer rotation, as it takes two years to get an alfalfa crop well established. Where sufficient land is available it is customary to keep it in alfalfa from three to five years. In one instance a very successful potato grower sows a mixture of clover and alfalfa seed in a 3-year rotation of potatoes, wheat, and clover, and alfalfa for hay.

Every potato grower should study carefully the best crop rotation for his own particular conditions, and having determined what crops best meet his requirements should rigidly adhere to them. Success in the conduct of any business is largely dependent on adherence to well thought out and executed plans which experience has shown to give the most satisfactory results.

PREPARATION OF THE LAND

Where the land is not subject to washing during the winter, it is usually preferable to plow a clover or alfalfa sod in late summer or early fall. A few successful potato growers prefer to plow their clover or alfalfa sod in the late spring, claiming that the new growth thus obtained when turned under deeply soon decays and becomes available to the growing plants. However this may be, it is believed that fall plowing is generally the more desirable practice, because it insures a more complete decay of the sod and in addition exposes the upturned soil to the sweetening and disintegrating influences of sun and wind, freezing and thawing, and rain and snow during the winter months.

In handling an alfalfa sod it is customary to crown the land in early fall. Crowning consists in plowing the land 3 or 4 inches deep, using a broad and sharp-edged point in order to cut off the

alfalfa crowns below the surface of the ground. An occasional disking or harrowing of the newly crowned land in the fall greatly facilitates the drying out of the alfalfa crowns and their consequent destruction, thereby materially lessening the cultural care of the potato crop during the ensuing season, at least in so far as it pertains to the eradication of the old alfalfa plants.

DEPTH TO PLOW

In some respects the question of depth to plow is a difficult one to answer because the depth of the surface soil and the character of the subsoil are in a large measure the determining factors. If the surface soil is deep and fertile it may be plowed to a depth of 10 inches or more (fig. 2), but if shallow it is not advisable to plow more than

FIG. 2.—Plowing with a caterpillar tractor a clover sod for the next year's potato crop. Presque Isle, Me., August, 1918

half an inch or an inch deeper than the surface soil. For example, if the surface soil is but 6 inches deep, it is best to plow to a depth of 6½ or 7 inches.

FITTING THE LAND

When the land is plowed in the fall, it should be left as plowed, but as soon as it is dry enough to work in the spring it should be gone over with a disk or spring-tooth harrow in order to conserve as much as possible of the winter's supply of moisture for the potato crop which is to follow.

When the land is plowed in the spring it is very desirable to disk or harrow it as soon as plowed, in order to prevent the loss of moisture as well as the baking of the newly turned soil and the consequent difficulty involved in putting it into condition at planting time.

A good general rule in fitting land for potatoes is to lose no opportunity in the spring to keep the surface soil broken up so as to prevent baking and the loss of moisture which later on may be badly needed by the plants. In the final preparation before planting the crop, no reasonable effort should be spared to put the soil in the very best mechanical condition possible. This may require the use of a cutaway or disk harrow; also a spring-tooth and a smoothing harrow. The character of the soil determines to a large extent the amount of horse or tractor labor necessary to put it in an ideal condition for planting. For example, a gravelly or sandy loam soil can be fitted with much less effort than a clayey loam soil, which has a strong tendency to run together after heavy rains and then to bake as it dries out.

Some growers assert that well-prepared land is 50 per cent of the solution of the problem in producing a larger yield of potatoes. Probably this is an overestimate of its value, but it must be evident that good soil preparation is a great asset in the production of a profitable crop.

APPLICATION OF PLANT FOODS

The question of a proper supply of plant food in the soil to insure a satisfactory yield of potatoes is one which must always receive the most careful attention of the grower if maximum yields are to be secured. The kind and the quantity of plant food that should be applied to the potato crop are in a certain measure determined by the previous treatment of the land on which the crop is to be grown and the fertilizing materials available for use by the grower. If a proper system of crop rotation has been followed and a clover or alfalfa sod has been turned under, that in itself is a guaranty of a fairly good supply of nitrogen, phosphorus, and potash, the three chemical elements the lack of which is most likely to limit the plant growth, and it will go far toward reducing the quantity of plant food necessary to apply in order to produce a maximum crop of potatoes.

Van Slyke states [2] that the tops and roots of red clover often contain 100 pounds each of nitrogen and potash and 50 pounds of phosphoric acid per acre. He further states (op. cit., p. 556) that a crop of alfalfa contains 120 pounds of nitrogen, 100 pounds of potash, and 30 pounds of phosphoric acid per acre.

Various estimates have been given as to the actual quantities of these three elements that are removed by a crop of potatoes. For purposes of comparison, three of these estimates are presented in Table 2. The first two sets of figures are based on a crop of 150 bushels per acre and the last on a maximum crop, for which Girard fails to give figures.

If we compare these data with those representing the chemical constituents in a crop of clover or alfalfa, it becomes evident at once that either of these leguminous crops returns a larger amount of nitrogen, phosphoric acid, and potash to the soil when plowed under than the potato crop removes. Such being the case, the question at once arises as to the necessity for any addition of plant food to the crop. The answer is that a relatively small part of these chemical

[2] Van Slyke, L. L. FERTILIZERS AND CROPS. 734 p., illus. 1917.

elements contained in the clover or alfalfa is immediately available to the plant; hence the necessity of applying a certain quantity of plant food that is immediately available.

TABLE 2.—*Quantity of nitrogen, phosphoric acid, and potash removed from the soil by a crop of 150 bushels of potatoes*

Source of estimate	Soil elements removed (pounds)		
	Nitrogen	Phosphoric acid	Potash
Van Slyke[1] (p. 613)	31.5	13.5	45.0
Woods and Bartlett[2]	27.8	12.0	43.5
Girard[3]	98.7	22.5	163.4

[1] Van Slyke, L. L. FERTILIZERS AND CROPS. 734 p., illus. 1917.
[2] Woods, C. D., and Bartlett, J. M. EXPERIMENTS WITH POTATOES. Me. Agr. Exp. Sta. Bul. 57, p. 154–155. 1899.
[3] Girard, Aimé. RECHERCHES SUR LES QUANTITÉS DE MATIÈRES FERTILISANTES NÉCESSAIRES À LA CULTURE INTENSIVE DE LA POMME DE TERRE. Ann. Sci. Agron. s. 2, année 3, t. 2, fasc. 2, p. 261–280. 1897.

KINDS OF PLANT FOODS

Generally speaking, fertilizers may be divided into two well-defined groups, (1) organic fertilizers and (2) inorganic fertilizers. The first group embraces farm manures, dried blood, tankage, bone meal, cottonseed meal, and urea, the latter being classed as a synthetic compound. In the second group nitrate of soda and sulphate of ammonia until recently have been regarded as the chief sources of nitrogen, and superphosphate as the chief source of phosphoric acid, with muriate and sulphate of potash as the more usual sources of potash in the United States. Within a comparatively short time, however, the users of commercial plant foods have been introduced to a considerable number of synthetic plant-food compounds which as a rule run somewhat higher in nitrogen and phosphoric acid than the common commercial sources previously mentioned. These synthetic compounds embrace such additional forms of nitrogen as ammonium chloride, calcium nitrate, and those containing two forms of nitrogen, as, for example, leunasalpeter and calurea. A second group of these newer fertilizers contains two plant foods such as diammonphos and leunaphos, representing one form of nitrogen and phosphoric acid, potassium nitrate containing nitrogen and potash, and another form, ammonium-potassium-nitrate, representing two forms of nitrogen with potash. A third group is represented by five forms of nitrophoska in which the nitrogen varies in its proportion of nitrate and ammonia and in water-soluble phosphoric acid.

Where farm manures are available they may be used at the rate of 10 to 15 tons per acre.

Complete reliance should not be placed on farm manures in the fertilization of land for potatoes, as they are not well-balanced fertilizers. Well-preserved barnyard manure should contain approximately 10 pounds each of nitrogen and potash and 5 pounds of phosphoric acid per ton. The application, therefore, of 10 tons per acre would be equal to 100 pounds each of nitrogen and potash and 50 pounds of phosphoric acid, a quantity considerably in excess of the need of a normal crop, but not that of a maximum one. It

must be remembered that a considerable part of the plant food contained in farm manures is not available the first season. It is therefore desirable on soils known to be deficient in phosphorus to reenforce the manure by applying from 400 to 600 pounds of commercial fertilizer analyzing approximately 2 per cent of nitrogen, 12 per cent of phosphoric acid, and 2 per cent of potash, or 200 to 300 pounds of a 4–24–4 fertilizer. This insures an immediately available supply of the three elements most commonly lacking in the soil and necessary for satisfactory plant growth. On soils known to be infested with potato-scab organisms it is generally not advisable to use farm manures, as it is almost certain to increase the percentage of scab-infected tubers.

On soils deficient in organic matter the application of farm manures is, for several reasons, especially beneficial to the crops which are grown upon them. This is particularly true in respect to the potato crop. The principal benefits accruing from the use of farm manures are (1) the addition to the soil of a considerable quantity of plant food, (2) an improvement of its physical properties, (3) its increased moisture-holding capacity, and (4) the increased bacterial action of the soil flora, particularly of the nitrifying organisms.

Where farm manures are not available, or where, if obtainable, the price is prohibitive, commercial fertilizers are found to be a fairly satisfactory substitute on lands well supplied with organic matter.

In some of the intensive potato-production centers commercial fertilizers are used with great prodigality. An application of 1 ton per acre of a 7–6–5 or a 5–8–7 fertilizer [3] is the rule rather than the exception, and some growers use as high as 3,000 pounds per acre.

Within the last few years some fertilizer manufacturers have offered for sale double and triple strength fertilizers. The advantage of using such a concentrated fertilizer is that it reduces freight charges and lessens the cost of handling and applying it. Instead of applying 1 ton of a 5–8–7 fertilizer, one can now use one-third ton of a 15–24–21 fertilizer. The only precaution necessary is to apply it in bands as suggested on page 9.

In the Atlantic Coast States it has been found that better results are obtained from a fertilizer in which half the nitrogen content is derived from nitrate of soda or sulphate of ammonia, or, better still, from both, and the remainder from an organic source such as fish scrap, cottonseed meal, tankage, or dried blood. The reason for this is that the nitrogen content of the nitrate of soda and sulphate of ammonia is immediately available, and owing to the ease with which it may be leached out of the soil or escape as a gas, the plants are not provided with a constant supply of this element throughout the growing season. The nitrogen content of cottonseed meal, fish scrap, or other organic forms is more slowly available and therefore serves as a source of food supply when the other is exhausted.

Where a proper system of crop rotation is followed, an application of 1,000 to 1,800 pounds of a 4–8–4 fertilizer should supply sufficient plant food to produce a maximum crop of potatoes.

[3] The figures 7–6–5 and 5–8–7 refer to the percentages of nitrogen, phosphoric acid, and potash that the fertilizer contains.

The present discussion of the use of commercial fertilizers is intended to apply to the New England States, Pennsylvania, Ohio, West Virginia, and certain portions of New York. The use of commercial fertilizers in western New York is by no means common, but it is on the increase. The same is true of some parts of Pennsylvania, Ohio, and West Virginia. Growers in Michigan, Wisconsin, and the States farther west are as yet but small users of these fertilizers, although there is little question that their judicious use would increase the yield in most cases.

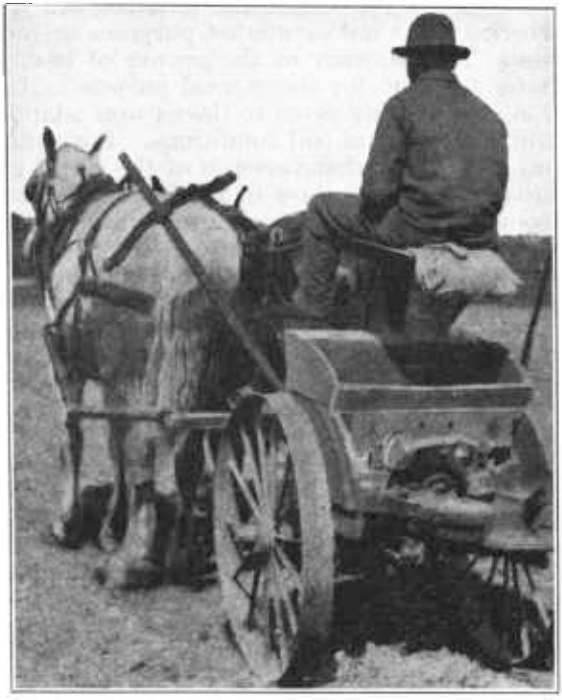


FIG. 3.—Applying the second installment of commercial fertilizer just before the plants appear above ground. By removing the plows and covering disks from the potato planter the fertilizer can be evenly distributed along the top of the ridge. Presque Isle, Me., June 5, 1918

METHODS OF APPLYING COMMERCIAL FERTILIZERS

Where commercial fertilizers are largely relied upon in the production of potatoes in the North, the potato planters used in putting in the crop are provided with a fertilizer-distributing attachment which opens a furrow, drops the fertilizer, and mixes it with the soil. This attachment is placed in front of the plow which opens the furrow for the reception of the seed pieces. As a rule, the whole quantity is applied at once, but there are a few growers who practice applying a part of the fertilizer when the crop is planted and the remainder just before the plants appear above ground. The usual method of making the second application is to distribute it on top of the row (fig. 3) and then mold the soil over it or else lightly cultivate it into the soil. Occasionally a grower is found who prefers to broadcast it over the field prior to plowing it, or a portion is broadcasted before fitting the land and the remainder is applied in the drill at the time of planting.

Whatever the way of applying the fertilizer, the grower should be careful to have it thoroughly mixed with the soil, in order to preclude any possibility of the seed pieces coming in direct contact with it.

A good rule to follow in the use of commercial fertilizers is to apply a reasonable excess above the actual requirements of a maxi-

A good rule to follow in the use of commercial fertilizers is to apply a reasonable excess above the actual requirements of a maximum crop. No one commercial fertilizer will meet the needs of all soils, and it is therefore necessary for each grower to study his own soil requirements. To apply a large quantity of nitrogen in an immediately available form is wasteful.

VARIETIES TO GROW

In deciding upon the variety to grow, it is necessary to consider the purpose for which the potatoes are to be produced; that is, whether for home or market purposes or for early or late consumption. The tendency of the grower of to-day is to plant fewer and fewer varieties for commercial purposes. Considerably more attention is now being given to the natural adaptation of varieties to certain regional and soil conditions. For example, on Long Island it has been found that varieties of the Rural group of potatoes do not succeed as well as those of the Green Mountain group;[4] hence varieties of the latter group are grown almost exclusively as a late crop. On the other hand, in western New York, particularly in Monroe, Livingston, Ontario, and Steuben Counties, varieties of the Rural group are practically the only late potatoes grown commercially. These two main groups or types of late potatoes are deserving of further mention, as they represent the leading late commercial varieties east of the Dakotas. The reason why the Green Mountain group succeeds best on Long Island and the Rural group in western New York, as interpreted by the writer, is as follows: The Green Mountain representatives are especially adapted to a cool and reasonably moist climate. The summer heat on Long Island is usually tempered by sea breezes, while the humidity of the atmosphere, owing to heavy fogs and dews as a result of proximity to water, provides conditions that are especially favorable to potatoes of this class. The Rural group does not thrive as well under these conditions, and as these potatoes are somewhat later in maturing and do not as a rule yield as heavy a crop, they are not looked upon with as much favor as those of the Green Mountain group. Another factor in favor of Green Mountain potatoes is that they are somewhat superior to those of the Rural group in table qualities.

The particular qualities which make the Rural group superior to the Green Mountain in western New York are as follows: A more vigorous constitution accompanied by a decidedly greater ability to withstand prolonged periods of heat and drought, which in that section are liable to occur during the latter part of July and to extend through a considerable part of August. Under such conditions varieties of the Green Mountain group, partly on account of their earlier habit of forming tubers and their greater expanse of foliage, have their vitality so seriously impaired that when more favorable growing conditions occur later they are unable to take advantage of them. On the other hand, varieties of the Rural group, having made a somewhat slower development and having smaller and

[4] See Stuart, William. GROUP CLASSIFICATION AND VARIETAL DESCRIPTIONS OF SOME AMERICAN POTATOES. U. S. Dept. of Agr. Bul. 176, reissue, 59 p., 19 pl. 1918.

thicker leaves, do not as a rule suffer sufficient injury to prevent their further development when the proper growing conditions once more prevail. Therefore for the reasons which have been stated, the leading late potatoes in New England, northern New York, Long Island, and New Jersey belong to the Green Mountain group, while in Pennsylvania, western New York, southern Michigan, Wisconsin, most of Iowa, and portions of Minnesota the Rural group leads. In other sections of Michigan, Wisconsin, and Minnesota either group or varieties can be grown successfully. In our judgment varieties belonging to the Green Mountain group of potatoes, because of superior table qualities and heavier yield, should be grown wherever they do equally well or better than those of the Rural group.

In the case of early varieties the Irish Cobbler easily leads in the northeastern portion of the United States. This variety is to a large extent very similar in its requirements to the Green Mountain group.

The question of varieties is important and should be considered carefully when deciding upon which one should be grown in order to get the best results. The desirability of confining one's efforts to a single variety, or at most to two varieties, one early and the other late, can not be overemphasized. The necessity of community action in this matter is extremely important, as it is much easier to attract buyers to a locality if carload lots of a single variety can be purchased than if each individual grower is producing a different sort.

There is another decided advantage in confining one's efforts to a single variety, or at most to two varieties, viz, that of becoming thoroughly familiar with the variety which is grown. It is much easier to keep it free from varietal mixtures, and there is greater likelihood that individual hill selection work will be carried on.[5]

TIME OF PLANTING

The time of planting is governed by a number of factors, chief among which may be mentioned that of the climatic conditions prevailing in a region during the planting season. As the chief object of this bulletin is to convey information to the grower on the production of late-crop potatoes, little attention is given to the early crop except to say that the seed should be planted as early as the danger from late spring frosts will permit. In the case of the late crop, however, an entirely different set of conditions obtains. In the extreme northern portion of some of the States concerned or at high altitudes where the entire growing season is required to produce a crop, planting must be done as early as the land can be prepared. On the other hand, in regions where the growing season is longer than that required to mature the crop, the time of planting should be determined by the character of the season which normally can be expected at any given time during the growing period of the

[5] See Stuart, William. SEED POTATOES AND HOW TO PRODUCE THEM. U. S. Dept. of Agr., Farmers' Bul. 1332, 17 p., illus. 1923.

plants. Careful investigations of the climatic requirements of the potato have shown conclusively that the critical period in the life of the plant occurs when it is developing its tubers. The drain upon the vital energies of the plants during this period is greater than at any other time, and it is very essential that the climatic conditions should be as favorable as possible when they reach this period in their development. Investigation has shown that if a protracted spell of heat and drought occurs during the period when the plant is developing its tubers, the yield is very materially lessened. On the other hand, if the weather is cool and there is a sufficient supply of moisture in the soil a good yield is practically assured, provided the plants have been given proper cultural attention. The problem, then, is to select a planting date which is most likely to subject the plants during their period of tuber development to the most favorable climatic conditions. Experience has demonstrated to the grow-

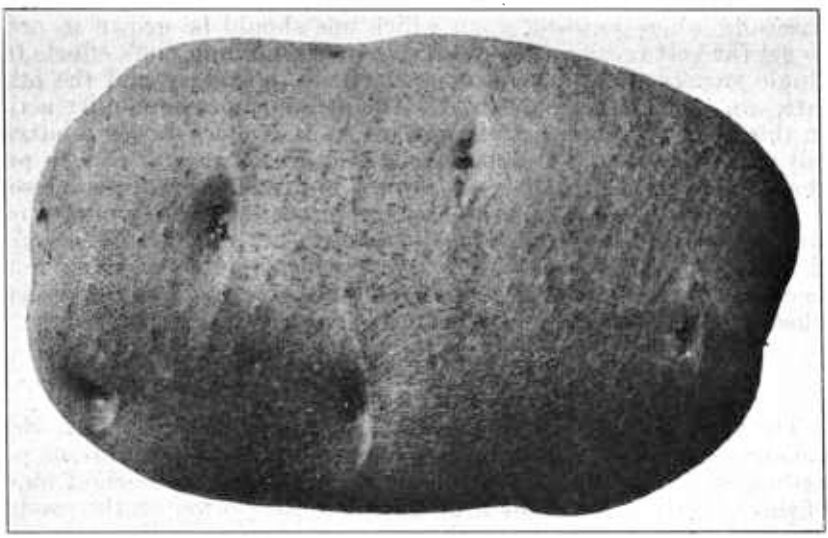


FIG. 4.—A good specimen of Green Mountain tuber

ers of western New York that, taking one year with another, they are able to secure better results from planting their crop from June 1 to 20 than from May 1 to 20. The reason for this is that throughout that region usually a period of four to six weeks of heat and drought occurs during the latter part of July and the early portion of August. If late potatoes were planted early in May they would be forming their tubers during this period. By delaying the planting until June the plants will not have reached the tuber-development stage, or if they have they will not be advanced sufficiently to sustain serious injury from any usual amount of heat and drought.

Conditions similar to those in western New York prevail in certain portions of Ohio, Michigan, Wisconsin, and other Middle Western States. The time of planting is therefore of considerable importance and should be given very careful attention by the grower if maximum results are to be secured.

IMPORTANCE OF GOOD SEED

The importance of planting good seed potatoes can hardly be overemphasized. The customary practice of using what is left from the previous season's crop, after having marketed or consumed the best, must be discontinued if the present quality and yield of the potato are to be materially improved. The grower can not expect to get maximum yields from inferior seed stock any more than the dairyman can expect to get maximum milk yields from scrub cows.

Good seed may be described as that which is pure with respect to the variety; is produced by healthy, vigorous, heavy-yielding plants

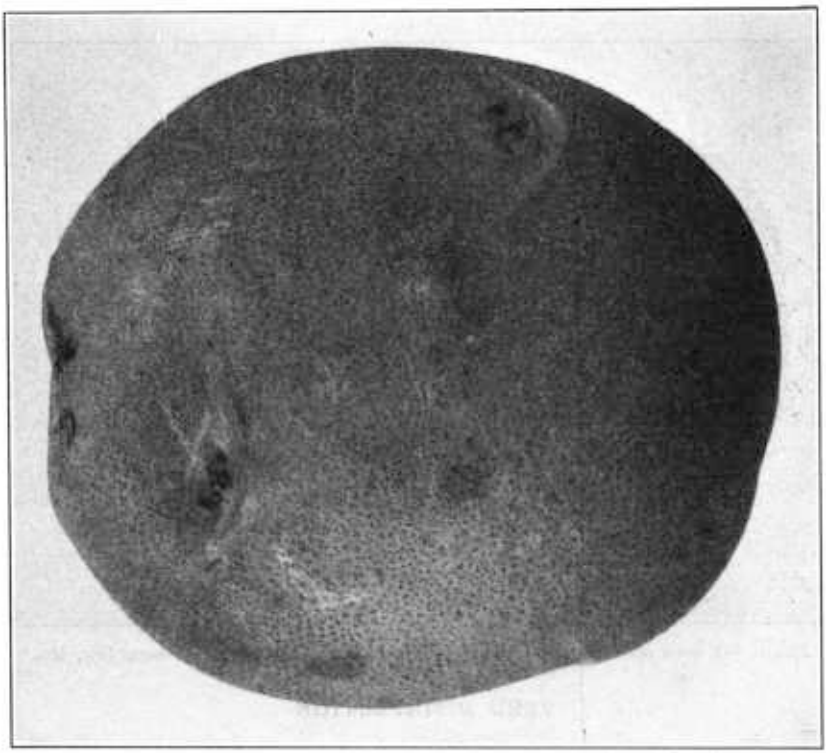


FIG. 5.—A good specimen of Rural New Yorker No. 2. (Natural size)

grown under favorable climatic conditions; and is somewhat immature, reasonably uniform in size and shape (figs. 4 to 7), and firm and sound, with the first sprouts beginning to develop at planting time. Seed of this character is now procurable in somewhat limited quantities from growers who specialize in seed production in Maine, Vermont, New York, Maryland, West Virginia, Wisconsin, Minnesota, North Dakota, South Dakota, Nebraska, Wyoming, Montana, Colorado, Idaho, Oregon, Washington, and California. In some States such seed is designated as "certified seed," which implies that the crop has been inspected once or twice during the growing season and has been found to be free from varietal mixtures and

relatively so from diseases which are communicable to the crop grown from it. A final inspection of such seed is made either at the time of harvesting the crop or after it has been stored. At this time the tubers are examined in order to determine their relative freedom from external and internal diseases, their conformity to the type of the variety they represent, and their general desirability for seed purposes. The average acre yield of the crop is also considered. A low yield disqualifies such stock for seed purposes.

Certified seed necessarily commands a considerable premium over that which has not been inspected, but the extra cost is slight as compared to the increased yields which may be expected from the use of good seed and the crop insurance which it affords.

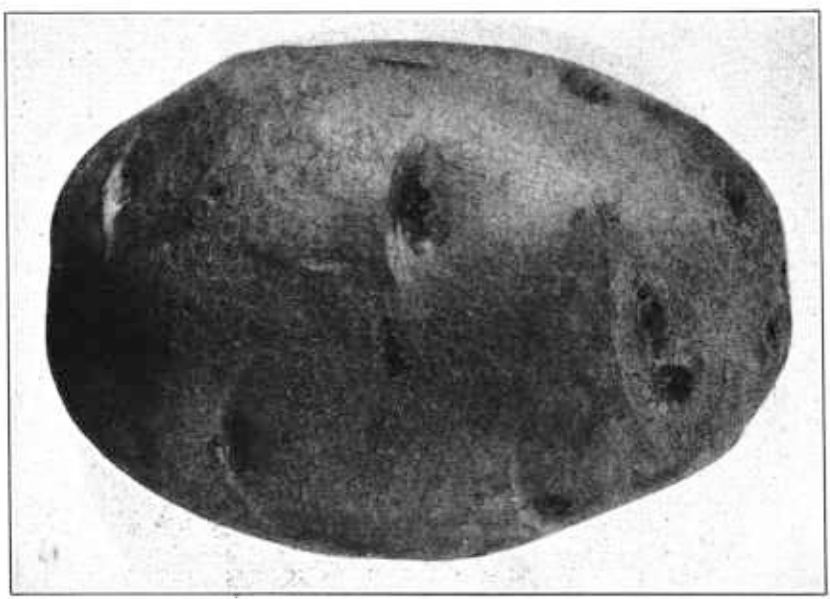


FIG. 6.—A good specimen of the Early Ohio potato as grown at Presque Isle, Me.

SEED DISINFECTION

The disinfection of seed prior to planting it should be regarded as a necessary part of the operations involved in potato culture, at least in regions in which the soil is not generally infested with potato-scab and black-scurf (Rhizoctonia) organisms. Aside from the labor involved the cost of the treatment is comparatively slight. The treatment consists in immersing the uncut seed in a solution of formaldehyde or corrosive sublimate from 1½ to 2 hours. These solutions should be made up according to the following formulas and the potatoes treated as suggested:

Formaldehyde treatment.—Add 1 pint of formalin to 30 gallons of water. Soak the potatoes in this solution from 1½ to 2 hours. Remove and spread them out to dry on a disinfected floor or in disinfected receptacles.

Corrosive-sublimate treatment.[5]—Dissolve 4 ounces of mercuric chloride (corrosive sublimate) in 30 gallons of water. Soak the potatoes as in the preceding treatment and dry in the same manner.

Hot-formaldehyde treatment.—Although the hot-formaldehyde treatment is a comparatively new method of seed-potato disinfection it may now be considered as well out of the experimental stage and worthy of more general adoption. It differs from the old method in that 2 pints instead of 1 pint of formalin are added to each 30 gallons of water and that the solution is heated. The original recommendation was to maintain the solution at a temperature ranging from 118° to 122° F. and to immerse the seed potatoes for about 3 minutes, remove and pile them up and cover with an old blanket or canvas for an hour and then spread out to dry. The latest recommendation is to maintain the solution at a temperature ranging from 124° to 125° F. for about the same period of treatment. The higher temperature is regarded as necessary to destroy effectively the sclerotia of Rhizoctonia.

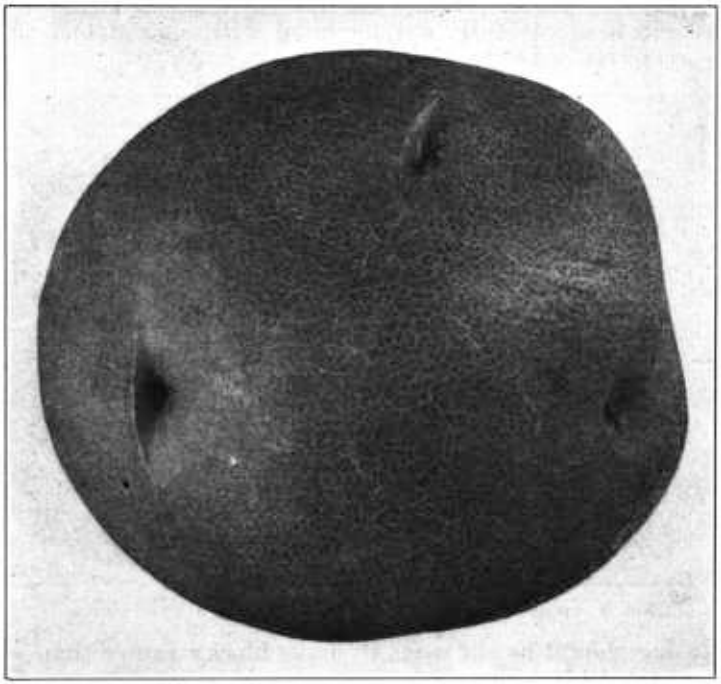


FIG. 7.—A good specimen of the Idaho Rural potato as grown at Jerome, Idaho

The corrosive-sublimate treatment is the more troublesome one to use and is also the more expensive, but it is the more effective against the black scurf; therefore it is recommended for the treatment of tubers showing such infection.

For scab disinfection alone the formaldehyde treatment is to be preferred, because formaldehyde is a nonpoisonous substance readily diluted with water; it can be used in metal as well as wooden con-

[5] Mercuric chloride dissolves very slowly in cold water, but rather quickly in hot water. It is desirable, therefore, to dissolve the crystals in a small quantity of hot water and then add sufficient water to make the required volume. Only wooden or earthen vessels should be used. The solution is very poisonous if taken internally; therefore great care must be taken to keep animals from drinking it. The same solution should not be used more than four times, as its strength rapidly decreases.

tainers, and it does not lose its strength, thus permitting the treating of larger quantities of potatoes in a given volume of solution.

In addition to the disinfectants mentioned, certain organic mercury compounds now available are gradually coming into favor, largely, it is believed, because of the ease of applying them. The treatment consists in dipping the tubers or cut seed into the mercury solution, merely taking the precaution of insuring thorough contact of the entire surface of the potatoes with the liquid. The organic mercury treatment is somewhat more expensive, so far as materials are concerned, than the first two mentioned.

CUTTING THE SEED

Most seed potatoes are cut by hand rather than with automatic seed cutters, but the continued improvement of these automatic seed-cutting devices is causing a tendency toward an increase in their use in spite of the fact that the work they do is not so satisfactory as the work done by hand. No automatic seed-potato cutter which has yet been devised is able to distinguish between weak eyes, strong eyes, or no eyes at all in a seed piece; hence a certain percentage of seed pieces cut by the machine will not produce plants, or if they do, the plants will be weak. On the other hand all seed pieces which have been carefully and properly cut by hand will contain one or more strong eyes. (Figs. 8 to 12.)

FIG. 8.—Irish Cobbler seed potato weighing 3 ounces

The tuber should be cut in such a fashion as to produce blocky seed pieces rather than wedge-shaped pieces. The advantage of the blocky seed piece is that it is handled better in the planter and is less likely to dry out or to decay in the ground if weather conditions are unfavorable.

It is generally desirable to use a seed piece of liberal size, weighing from 1¼ to 1½ or 2 ounces. As a rule, such a seed piece will contain from one to three eyes. A 3 to 4 ounce tuber cut into two pieces or into three pieces if it weighs 4 ounces has given very satisfactory results.

As a rule potato growers arrange to cut their seed potatoes at about the time when they are required for planting, but some growers who have large acreages or who are limited in the time and labor required in preparing the potatoes for planting, have found it more economical as well as more convenient to cut their seed potatoes in advance of the time for planting, and when other farm tasks are not so pressing as during the potato-planting season. When this prac-

lowed care must be taken in handling the freshly cut seed in order to avoid injury from overheating until it is thoroughly cured; that is, until the cut surfaces become dry. The drying is usually facilitated by dusting the freshly cut seed with one of the absorbents previously mentioned and then placing the seed pieces in slatted crates or flats or spreading them out in a thin layer on the floor. However handled, they should be turned over once or twice during the first 24 hours and once during each of the two following days, after which, depending somewhat on the weather, of course, the cut surfaces are sufficiently dry for the seed pieces to be stored in sacks, barrels, or bins until needed for planting. Some growers prefer to handle their seed in this manner rather than to cut it as needed, claiming that they obtain much better results. But whatever the method adopted it is important to remember that if the weather is warm freshly cut seed develops heat very rapidly and that, under these conditions, its vitality is quickly injured. Many a poor stand has been attributed to seed of poor quality when it was the direct result of the improper handling of the cut seed.

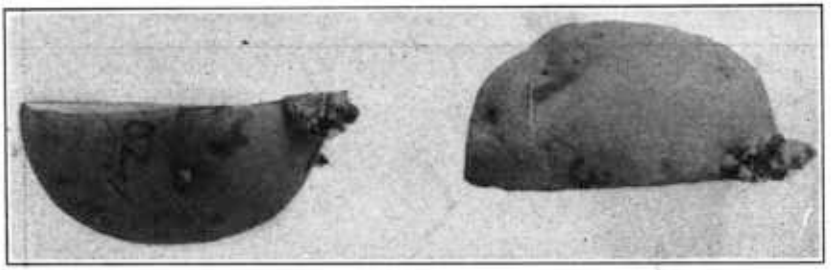


FIG. 9.—The halved pieces of one of the 3-ounce tubers, shown in Figure 8, giving a 1½-ounce seed piece

RATE OF PLANTING

The rate or distance of planting is largely determined by the natural fertility of the land, its moisture-holding capacity, the supply of available plant food, which is to be applied to the crop, and the variety grown. In Aroostook County, Me., early varieties, such as the Irish Cobbler, Triumph, and Early Rose, are usually planted in rows from 32 to 34 inches apart and from 8 to 12 inches apart in the row. The Green Mountain, which is the leading late variety of that region, is planted in rows from 34 to 36 inches apart and the plants in the row 10 to 14 or more inches apart, depending on the size of the seed piece used. Table 3 shows the number of seed pieces required for an acre when planted at different distances. A study of the data presented in this table shows that the closest spacing, 30 by 8 inches, would require 26,136 seed pieces to the acre as compared with 14,520 for a spacing of 36 by 12 inches, which is the more common planting practice. The wider spacings included in Table 3 are not infrequently encountered in the dry-farming sections of the West, where the deficiency in moisture makes it impossible to grow potatoes successfully at the distances usual in the humid areas of the United States.

A comparison of the two extremes in spacing shows 26,136 seed pieces in one and 3,630 in the other, the ratio between the two being

1 to 7.2; in other words, the number of seed pieces required to plant an acre 30 by 8 inches apart would plant 7.2 acres 48 by 36 inches apart.

TABLE 3.—*Number of seed pieces required to plant an acre of potatoes at different spacings*

Rows apart	Pieces of potato seed required at stated spacing distances (number)							
	8 inches	10 inches	12 inches	14 inches	16 inches	18 inches	24 inches	36 inches
30 inches	26,136	20,909	17,424	14,935	13,068	11,616	8,712	5,808
32 inches	24,502	19,602	16,335	14,001	12,251	10,890	8,168	5,445
34 inches	23,061	18,449	15,374	13,178	11,531	10,249	7,687	5,125
36 inches	21,780	17,424	14,520	12,446	10,890	9,680	7,260	4,840
42 inches	18,669	14,935	12,446	10,668	9,334	8,297	6,223	4,149
48 inches	16,335	13,068	10,890	9,334	8,168	7,260	5,445	3,630

The number of bushels of seed employed in planting an acre of potatoes varies considerably in different parts of the country. Roughly stated, the quantity actually used varies from 5 to 18

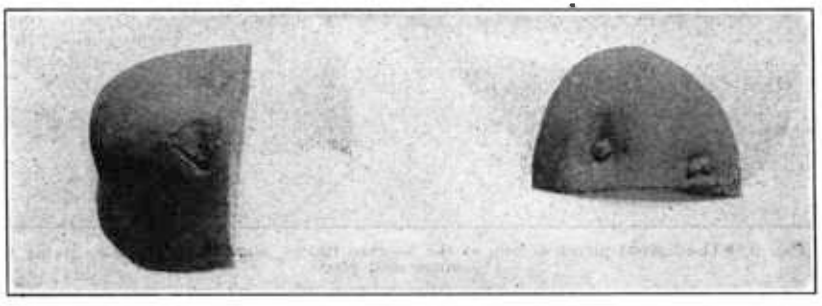


FIG. 10.—One of the halved pieces quartered, giving a ¾-ounce seed piece. Compare with Figure 9

bushels per acre. There are occasional growers who use as many as 24 bushels per acre. The average quantity of seed planted per acre in the United States was estimated several years ago by the Bureau of Crop Estimates at 8.6 bushels. As a rule, the smaller quantities are used by the southern truck grower, who is generally obliged to pay a high price for seed stock on account of his distance from the source of its production and the season of the year at which he has to have it delivered. In Aroostook County, Me., the common practice is to plant from 5 to 6 barrels of seed per acre, or from 825 to 990 pounds (13.7 to 16.5 bushels). In order to afford a ready reference to the actual quantity of seed required to plant an acre with seed pieces of definite weights at a given distance between plants, Table 4 has been prepared to cover seed pieces ranging from half an ounce to 2 ounces in weight. It will be noted that plantings made at close intervals with seed pieces ranging from 1¼ to 2 ounces require quantities of seed very greatly in excess of those ordinarily used. On land well supplied with organic matter, an abundant supply of available plant food, and moisture, the use of large-sized pieces or whole tubers from 1½ to 2 ounces in weight will usually prove a profitable investment.

A safe general rule to follow in planting potatoes is to increase or decrease the distance between the rows, as well as the hills, in accordance with the size of the seed piece used, the variety grown, the fertility of the soil, its moisture-holding capacity, and the average normal rainfall that may be expected when the plants are developing their tubers. The nearer the soil and weather conditions approach the ideal, the larger the seed piece and the closer the planting. Early-maturing varieties may be planted more closely than late-maturing sorts, because the plants, as a rule, do not grow as large.

A study of Table 4 discloses the fact that the quantity of seed required for planting an acre of potatoes with 2-ounce pieces at a spacing of 30 by 8 inches is more than 54 bushels. When the spacing in the row is doubled—that is, made 30 by 16 inches—only half this quantity will be required. It is believed that when seed pieces

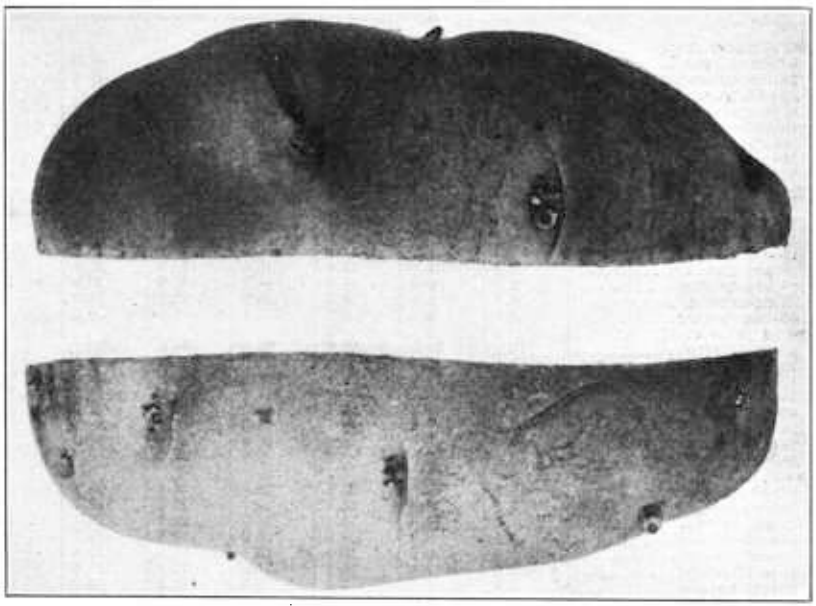


FIG. 11.—First step in cutting a large-sized Green Mountain tuber into seed pieces

averaging 2 ounces in weight are used, a spacing of 12 to 14 inches may be expected to give better results than 10 to 12 inches. In other words, the spacing of the plants in the row is to a large extent governed by the size of the seed piece used. It should further be remembered that in the semiarid regions of the West, where a moisture deficiency is almost certain to occur, wider spacing must be practiced than in the humid sections of the East.

In northern Maine, where large acreages of potatoes are grown for seed, many growers make a practice of planting Irish Cobbler seed pieces 32 by 8 or 32 by 10 inches apart. Such spacing, according to Table 3, will require 24,502 and 19,602 seed pieces, respectively, for an acre. By referring to Table 4 it is found that with seed pieces averaging one-half ounce in weight and spaced 34 by 8 inches, it will require 12 bushels and with ¾-ounce seed pieces 18 bushels

to plant an acre. When seed pieces of the same size are spaced 34 by 10 inches, the quantities required are 9.6 and 14.4 bushels, respectively. As has been previously stated, the practice in northern Maine is to plant from 5 to 6 barrels of seed per acre, or 13.75 to 16.5 bushels, respectively, which would indicate that the average seed piece used by the Maine potato grower is approximately three-fourths ounce in weight. It is believed that better results would be secured if larger sized seed pieces were used.

TABLE 4.—*Number of bushels of potatoes required to plant an acre at different spacings with seed pieces of various sizes*

Spacing of rows and seed pieces	Seed required, the average weight of seed pieces used being as given (bushels)						
	½ ounce	¾ ounce	1 ounce	1¼ ounces	1½ ounces	1¾ ounces	2 ounces
Rows 30 inches apart:							
8-inch spacing	13.6	20.4	27.2	34.0	40.8	47.6	54.4
10-inch spacing	10.9	16.3	21.8	27.3	32.6	38.1	43.6
12-inch spacing	9.1	13.6	18.2	22.7	27.2	31.8	36.3
14-inch spacing	7.8	11.7	15.6	19.4	23.3	27.2	31.1
16-inch spacing	6.8	10.2	13.6	17.0	20.4	23.8	27.2
18-inch spacing	6.0	9.1	12.1	15.1	18.2	21.2	24.2
24-inch spacing	4.5	6.8	9.1	11.3	13.6	15.9	18.2
36-inch spacing	3.0	4.5	6.0	7.5	9.1	10.6	12.1
Rows 32 inches apart:							
8-inch spacing	12.8	19.1	25.5	31.9	38.3	44.7	51.1
10-inch spacing	10.2	15.3	20.4	25.5	30.6	35.7	40.8
12-inch spacing	8.5	12.8	17.0	21.3	25.6	29.8	34.0
14-inch spacing	7.3	10.9	14.6	18.2	21.9	25.5	29.2
16-inch spacing	6.4	9.6	12.8	16.0	19.2	22.4	25.6
18-inch spacing	5.7	8.5	11.3	14.2	17.0	19.8	22.7
24-inch spacing	4.3	6.4	8.5	10.6	12.7	14.9	17.0
36-inch spacing	2.8	4.2	5.7	7.1	8.5	9.9	11.3
Rows 34 inches apart:							
8-inch spacing	12.0	18.0	24.0	30.0	36.0	42.0	48.0
10-inch spacing	9.6	14.4	19.2	24.0	28.8	33.6	38.4
12-inch spacing	8.0	12.0	16.0	20.0	24.0	28.0	32.0
14-inch spacing	6.9	10.3	13.7	17.1	20.6	24.0	27.4
16-inch spacing	6.0	9.0	12.0	15.0	18.0	21.0	24.0
18-inch spacing	5.3	8.0	10.7	13.3	16.0	18.7	21.4
24-inch spacing	4.0	6.0	8.0	10.0	12.0	14.0	16.0
36-inch spacing	2.5	3.8	5.0	6.3	7.6	8.8	10.1
Rows 36 inches apart:							
8-inch spacing	11.3	17.0	22.7	28.4	34.0	39.7	45.4
10-inch spacing	9.1	13.6	18.1	22.7	27.2	31.7	36.3
12-inch spacing	7.6	11.3	15.1	18.9	22.7	26.5	30.2
14-inch spacing	6.5	9.7	13.0	16.2	19.4	22.7	25.9
16-inch spacing	5.7	8.5	11.3	14.2	17.0	19.8	22.7
18-inch spacing	5.0	7.6	10.1	12.6	15.1	17.6	20.2
24-inch spacing	3.8	5.7	7.6	9.5	11.3	13.2	15.1
36-inch spacing	2.5	3.8	5.0	6.3	7.6	8.8	10.1
Rows 42 inches apart:							
18-inch spacing	4.3	6.5	8.6	10.8	13.0	15.1	17.3
24-inch spacing	3.2	4.9	6.5	8.1	9.7	11.3	13.0
30-inch spacing	2.6	3.9	5.2	6.5	7.8	9.1	10.4
36-inch spacing	2.2	3.2	4.3	5.4	6.5	7.6	8.6
Rows 48 inches apart:							
18-inch spacing	3.8	5.7	7.6	9.5	11.3	13.2	15.1
24-inch spacing	2.8	4.2	5.7	7.1	8.5	9.9	11.3
30-inch spacing	2.3	3.4	4.5	5.7	6.8	7.9	9.1
36-inch spacing	1.9	2.8	3.8	4.7	5.7	6.6	7.6

PLANTERS

In most commercial potato-producing regions in the North and West, horse-drawn machine planters are extensively used. There are some localities, however, where hand planters are still in use. The machine planters are of two general types, the picker and the two-man type. The picker type of machine requires but one man to operate it. The seed pieces are picked up by forks attached to a

revolving vertical disk which passes through a compartment containing the cut seed. The seed piece thus picked up by each fork is stripped off as it passes between two fingerlike attachments and falls into the dropping tube. Accuracy in planting is largely dependent on the uniformity in size and shape of the seed pieces used.

In the operation of the two-man planter the seed pieces are raised singly from the hopper by a revolving cogged wheel and deposited in the pockets of a revolving horizontal disk, which discharges the seed piece from each pocket as it passes over the dropping tube. The accuracy of this machine is dependent upon the ability of the second man, who sits in the rear, to see that each pocket has a seed piece and to remove any extra pieces that may be in others. (Fig. 13.) With a good man in the rear, this type of machine will plant 100 per

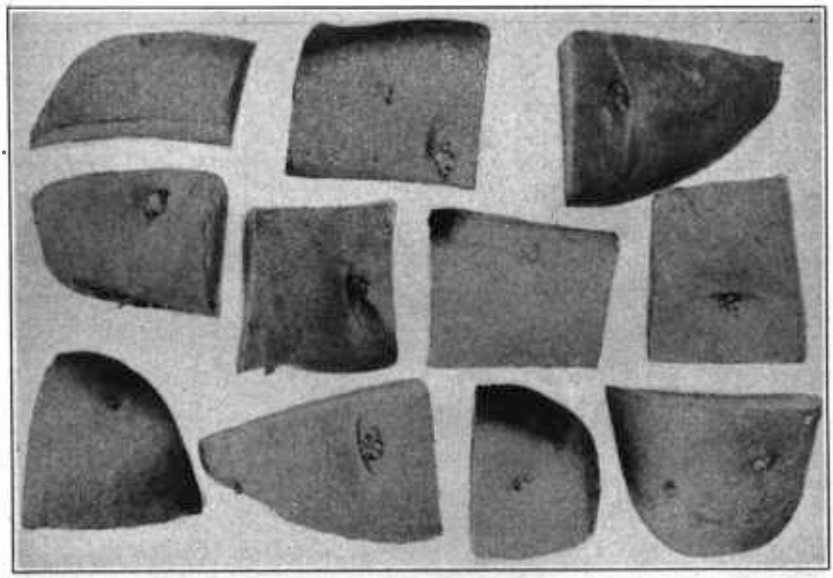


FIG. 12.—Second and final steps in cutting large tubers into seed pieces when cutting to single-eye pieces or as nearly so as possible

cent perfect, whereas with the picker type if a fork fails to get a seed piece or another fork spears two or more pieces there is no one to correct these mechanical errors.

The advantages and disadvantages of the picker and the two-man type of planter are as follows: (1) The picker type requires only one man to operate it; (2) the picker type being entirely automatic in its operation it is possible to drive somewhat faster, thereby planting from 1 to 2 more acres a day than the two-man type; but (3) the two-man planter insures a somewhat better stand of potatoes than the picker type.

The hand planter has the advantage of being cheap and consequently within the reach of every grower. On well-prepared sandy loam soils an active man can plant an acre or more a day.

Most areas of 1 acre or less will be planted with a hand planter or by merely dropping the seed pieces in an open furrow and cover-

ing them with the hoe, a cultivator, or plow. For the most part, the family supply of potatoes is grown from seed pieces dropped by hand rather than with any mechanical device.

DEPTH OF PLANTING

There is no general rule as to the depth to plant the seed pieces or sets which will give the best results under all conditions. In other words, the character of the soil, the season at which the planting is done, the method of culture practiced, and the climatic conditions likely to prevail during the growth of the plant are the determining factors. For example, on heavy cold soil the depth should not be more than 3 or 4 inches if level culture is to be practiced, or 2 to 3 inches if the ridge method is followed, whereas on a light sandy loam

FIG. 13.—A 2-man planter. This particular planter does not have a fertilizer-distributing attachment

soil, which is likely to be deficient in moisture, a depth of 4 to 6 inches will prove more satisfactory for level culture and 3 or 4 inches for ridge culture. Each grower must regulate the depth of planting to conform to his own peculiar conditions. It must be remembered that in very early planting the depth should be less than in late planting, because the ground is colder and the crop is less likely to suffer from heat or drought.

LEVEL OR RIDGE CULTURE

Broadly speaking, but two systems of culture are practiced in the areas producing late potatoes in the United States, viz, the level and the ridge. The system followed is determined to a large extent by the seasonal conditions which normally prevail in a given part of the

country during the growing period of the plant and particularly during the latter portion of the season. If the period in which the plants are developing tubers is likely to be hot and dry, level culture should be practiced, but if the reverse is true ridge culture may give better results. Another controlling factor is that of the weather at the time of harvesting the crop. Where rainy weather may be expected, the ridge system will prove most satisfactory, because the land dries out quicker, thereby making harvesting operations possible, when under level culture the digging of the crop might be seriously delayed.

In general, the ridge system of culture is largely confined to Maine, western New York, and those irrigated sections of the West where it is necessary to provide furrows in which to run the irrigation water. Throughout Michigan, Wisconsin, Iowa, and Minnesota the level system of culture is commonly practiced.

CULTIVATION

The main objects of cultivation are to destroy weeds, conserve moisture, liberate plant food, aerate the soil, and, in consequence of keeping it in a loose, friable condition, to encourage root action. The prevention of weed growth may be very greatly facilitated by harrowing with a spike-tooth harrow lengthwise of the rows a week or 10 days after planting, or if the surface of the soil has not been compacted a weeder may be used with almost equally good results. This operation should be repeated as often as may be necessary to subdue weed growth or to maintain an earth mulch until after the plants are well above ground. If a harrow is used when the plants are coming up, it should be one which is so constructed as to permit slanting the teeth backward; otherwise the plants may be injured seriously. When the plants are sufficiently developed to define the rows the soil between them should be cultivated as deeply as possible, care, of course, being taken not to cause the plants injury through root pruning. The next and each subsequent cultivation should be shallower than the preceding one and farther and farther away from the plants. Whether the implement used be a shovel plow, horse hoe, or a one or two horse cultivator, it should be adjusted so as to throw some soil toward the plants, the object being to keep the surface of the soil stirred or covered with loose soil in order to conserve moisture and prevent weed growth. (Figs. 14 and 15.)

With the ridge system cultivation can be continued later than where level culture is practiced, because in the former case the roots of the potato plants are very largely, if not wholly, confined to the ridged earth, and the furrow between may therefore be cultivated with more or less impunity and slight quantities of soil "winged" toward the plants. On the other hand, in level cultivation the roots soon spread out through the soil between the rows, making cultivation a rather hazardous practice on account of the almost certain heavy root pruning and consequent injury to the crop that inevitably results. Careless cultivation or its continuance too late in the season has been responsible for many a poor yield. A single cultivation when the soil is well filled with roots may, in the absence of a rain soon after cultivation, reduce the yield fully one-half. It is important, therefore, that the cultivation of the potato shall

be intelligently performed to the end that the crop may receive the maximum benefit and minimum amount of injury from it. The aim should be to give as thorough tillage as possible in the early development of the crop, so as to afford the most favorable conditions for the completion of the growth of plants and tubers. As a rule, cultivation should cease soon after the tubers have set. (Fig. 16.)

SPRAYING

The object of spraying the potato plant is to protect its foliage from injury resulting from attacks of fungous diseases and insect enemies.

The principal fungous diseases of the foliage which can be controlled by spraying with a fungicide are the early and late blights. The former is generally more prevalent and causes greater injury

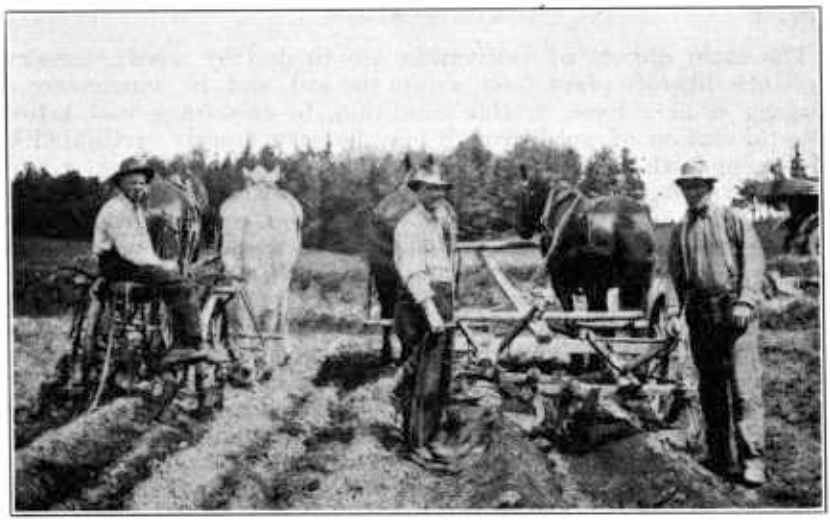


FIG. 14.—First cultivation and horse hoeing of the potato crop in Aroostook County, Me., June 5, 1918

to the potato crop of the Middle West than in the East. Both the early and the late blights are capable of attacking the foliage, stem, and tuber of the plant, but under certain conditions they may not actually infect the tuber, though causing a decided reduction in yield whenever any considerable portion of the foliage is affected.

The early blight is not as easily or as completely controlled by applications of fungicides as the late blight. Thus far, Bordeaux mixture is the most efficient agency for the control of these two diseases.

The time and frequency of applying Bordeaux mixture are largely determined by the character of the season and the section of country in which the crop is being grown. Late blight, for example, seldom causes injury to the potato crop of the Middle West, except in the northern portion of the States east of the Mississippi River, and as a rule these States do not suffer from this fungous disease until

rather late in the growing season. In a measure the same statement is true of the early blight, especially with reference to the time of its development, but it does not apply as regards the infrequency of its attack, because it is usually prevalent, to some extent at least, practically every season. Owing to the above conditions and to a later date of planting in many of these areas it is not necessary to begin spraying for fungous diseases as early in the season as is done in some portions of the East where both the early and late blights may appear much earlier. This is particularly true with respect to the early blight, which on varieties planted for early marketing may attack the foliage the latter part of June or early in July. Generally speaking, few, if any, commercial growers spray their potato plants primarily for the purpose of controlling the early blight. Spraying is only general in localities in which the late blight occurs

FIG. 15.—Ridging the soil over the potato plants with a disk horse hoe in Aroostook County, Me., June 5, 1918

with more or less regularity. It should begin in the northern New England States early in July. In other sections, where the crop is planted later, it may be deferred somewhat.

The chief insect pests of the potato which prey upon the foliage are the Colorado potato beetle, the potato flea beetle, the potato leafhopper, and certain plant lice. The first two are leaf-eating and the last ones are sucking insects.

The Colorado potato beetle is readily controlled by spraying the foliage with some form of arsenical poison, such as lead arsenate, zinc arsenite, or Paris green.

The flea beetle is a much more difficult insect to handle, because it consumes less foliage and is not as easily poisoned as the Colorado beetle. It is most effectively held in check by keeping the foliage well covered with Bordeaux mixture. The potato leafhopper, although a sucking insect and amenable to the same insecticides as for

plant lice, is most effectively controlled by thorough spraying with Bordeaux mixture, which acts as a repellent. Plant lice, owing to the manner in which they take their food from the plant—that is, by sucking its juices—must be dealt with by applying what is known as a contact insecticide, such as kerosene emulsion, tobacco extract, or whale-oil soap. A proprietary compound sold under a trade name, which is in reality a strong decoction of nicotine sulphate, is generally considered the most satisfactory, as it is the most easily prepared and applied.

As a rule, in the late-blight sections the potato grower makes a practice of combining with Bordeaux mixture the arsenical poison used in destroying the Colorado beetle, thereby providing a more efficient protection against the flea beetle, because the leaves when covered with Bordeaux mixture are far less appetizing to the latter

FIG. 16.—A field of Irish Cobbler potatoes in full bloom, Caribou, Me., July, 1914. No further cultivation should be given

pest, and in addition to this the plants are protected against the early and late blights.

The following formula and brief directions are offered for the preparation and application of Bordeaux mixture:

5 pounds of copper sulphate (blue vitriol).
5 pounds of quicklime or dehydrated lime.
50 gallons of water.

Prepare the mixture in the following manner: Dissolve the copper sulphate and slake the quicklime in separate wooden or earthen vessels in 4 or 5 gallons of water. Dilute each lot to 25 gallons and then simultaneously pour them together into a third vessel, stirring the mixture vigorously as poured. Strain the mixture carefully before it goes into the spray tank, and apply it to the foliage of the plants with a spray pump capable of developing a strong pressure,

using a nozzle so constructed as to make a very fine and even distribution of the spray material. A spray-mixing platform with an elevated tank greatly lessens the labor involved in preparing Bordeaux mixture and in filling the spray tank. (Fig. 17.)

The object of spraying is to cover the foliage with the fungicide or insecticide so thoroughly as to preclude the possibility of fungous or insect pests causing any material injury to the plants. In addition to this, usually an indirect advantage is derived from spraying which is very often lost sight of. This is that well-sprayed plants seem to suffer very much less foliage injury from tipburn than unsprayed plants. It is claimed by some that the copper contained in the Bordeaux mixture serves as a stimulant to the plant, but however that may be, it has been many times demonstrated that in

FIG. 17.—Spray-mixing outfit used by the United States Department of Agriculture on Aroostook Farm, Presque Isle, Me. The pump is operated by a gasoline engine

seasons in which a long period of drought or heat has occurred the foliage of the sprayed plants suffers much less than the unsprayed ones, and the resultant yields are sufficiently greater, as a rule, to more than repay the grower for the cost of spraying.[6]

Where late blight is likely to occur, potatoes in the home garden may be protected by dusting them with dry Bordeaux mixture or some proprietary fungicide. Where insect protection alone is necessary, a mixture of dehydrated lime and Paris green at the rate of 1 pound of poison to 20 pounds of lime may be dusted over the plants. Used in liquid form, the milk of lime should be added to it to prevent injury. Dry materials may be applied with a dust-distributing can,

[6] For further information on the control of fungous diseases and insect pests of the potato, see Farmers' Bulletins 1349, "Increasing the Potato Crop by Spraying," and 1367, "Control of Potato Tuber Diseases."

or even by placing them in a cheesecloth bag and shaking over the plants. Liquid applications on a small plat may be made with a watering can or garden atomizer.

HARVESTING THE CROP

The harvesting season for the late crop of potatoes begins in September in the New England States and ends in November in the Middle West.

Except where a relatively small acreage is grown, the crop is harvested with an elevator type of digger. Where smaller areas are devoted to potato culture a simple plowlike digger may serve to harvest the crop. When this type of digger is provided with a device for rocking or agitating the fingerlike attachment in the rear,

FIG. 18.—The elevator type of digger, which in the New England States is usually operated with a pair of horses

which is designed to separate the tubers from the soil, fairly good work is done and the machine proves to be a very satisfactory substitute for the more expensive elevator digger.

Small areas are often harvested by the use of the ordinary turning plow for lifting the tubers out of the ground or by using a spading fork; in fact, a fork is exclusively used when selecting hills from which to start the seed patch.

The potato digger usually is operated with two horses in the New England regions, whereas in the West three or four horses are required to haul the machine when actually engaged in digging. These differences in horsepower requirements are largely due to the character of the soil on which the crop is grown and the system of culture practiced. A few years ago elevator diggers were placed on the market, the machinery of which is driven by a small gasoline

engine mounted on the digger, which simply operates the carrier and the vine-clearing device, the machine itself being hauled by two horses. This necessarily lightens the draft of the machine materially and makes it possible to dig a larger acreage. On the other hand, it adds very greatly to the first cost of the machine, and its use is not likely to become very general except with the larger growers in those regions in which the digger is operated with two horses. (Figs. 18 and 19.)

In Maine the tubers are gathered in wooden splint baskets, from which they are dumped into barrels and hauled to the storage house or shipping point. The empty barrels in either case are returned to the field. In western New York and in Michigan and Wisconsin

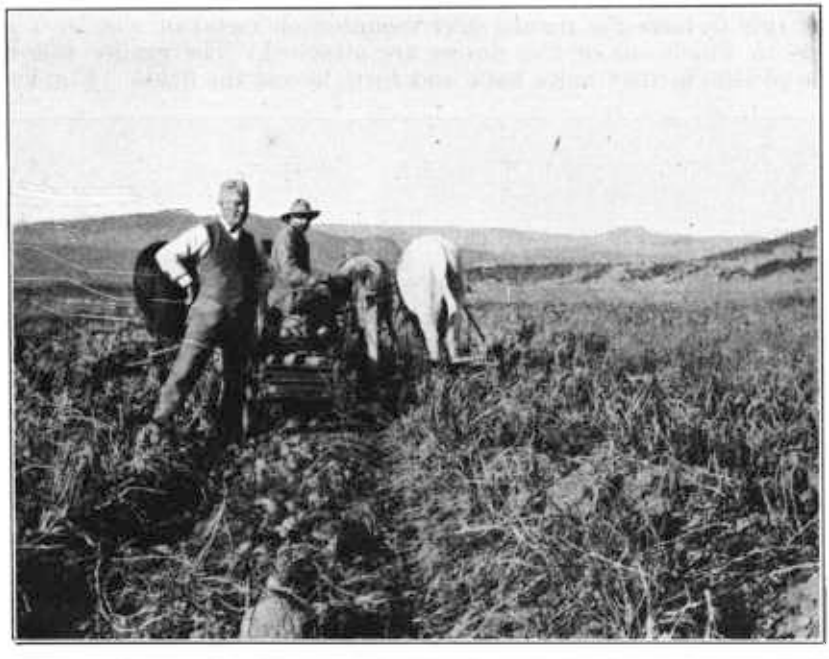


FIG. 19.—In the Central West and West three or four horses are generally used to haul the potato digger

it is quite generally the custom to gather the tubers in slatted crates, in which they are hauled direct to the shipping point or to the storage house. This method is considered much more satisfactory than that practiced in Maine, because it reduces the chance of rough handling, especially when the picker empties the first basket which goes into the barrel. The usual custom is to dump the potatoes into the barrel without making any pretense of tipping it in order to break the force of the fall. The injurious effect of such rough handling, especially if the tubers are somewhat immature, can be readily appreciated. Much of this injury could be avoided if a little care were taken in emptying the first two or three baskets by tipping the barrel or lowering the basket into the barrel before emptying it. In western Minnesota and points west of that territory the tubers are gathered in wire

baskets, from which they are either thrown on the grader, screened, and put in two-bushel sacks or from two to three baskets are emptied into each sack, which is then hauled to the storage house without tying (figs. 20 and 21), the grading in the latter case being done in the storage house as the crop is marketed.

In the East little grading is done in the field other than leaving the very small, scabby, diseased, sunburned, or badly cut tubers on the ground, to be gathered up later for starch making or for stock feed. Little, if any, greater care is exercised in this respect where the crop is sold directly from the field.

FIELD SIZING

In the West, where field sizing is most commonly practiced, it is the rule to have the potato sizer mounted on metal or wooden runners to which one or two horses are attached. The grader follows the pickers as they move back and forth across the field. (Fig. 22.)

FIG. 20.—Hauling potatoes from the field in untied sacks from which they are emptied directly into the storage house. Greeley, Colo.

Usually one operator can size and sack the potatoes gathered by three pickers. Where the crop is handled in this manner all the sound tubers are picked up at one operation. This device screens and separates the crop into two sizes, and the operator who manipulates it is supposed to remove all of the sunburned, diseased, and badly cut or bruised tubers as they pass over the screen, such tubers going into the culls. For a more detailed account of the grading and marketing of potatoes, see Farmers' Bulletins 753 and 1317.[7]

STORAGE

In all regions where late potatoes are produced on a commercial scale the problem of storage is an important one, as it is physically impossible as well as economically undesirable to attempt to market the entire crop in the autumn. The only way in which the potatoes

[7] More, C. T., and Dorland, C. R. COMMERCIAL HANDLING, GRADING, AND MARKETING OF POTATOES. U. S. Dept. of Agr., Farmers' Bul. 753, 43 pp. 1917.
Sherman, Wells A., Fiske, George B., and Miller, O. D. MARKETING MAIN-CROP POTATOES. U. S. Dept. of Agr., Farmers' Bul. 1317, 37 pp. 1923.

can be handled successfully so as to insure a uniform supply throughout the winter is to provide sufficient storage on the farm or at the shipping station for 65 to 75 per cent of the total crop. Every commercial grower should make such provisions as may be necessary to care for at least 75 per cent of his crop, and he would often find it convenient to be able to store all of his crop. Various types of storage places may be employed, such as pits, cheaply or substantially constructed dugouts, cellar pits where the houses have straw and earth covered roofs such as may be found in the arid or semi-arid regions of the West, or a similar type with water-tight roof which is in common use in the Middle West and some portions of the East, or the more expensive type of house such as one finds in Maine. Each grower must determine for himself which of these types of storage house is within his means and best meets his requirements.

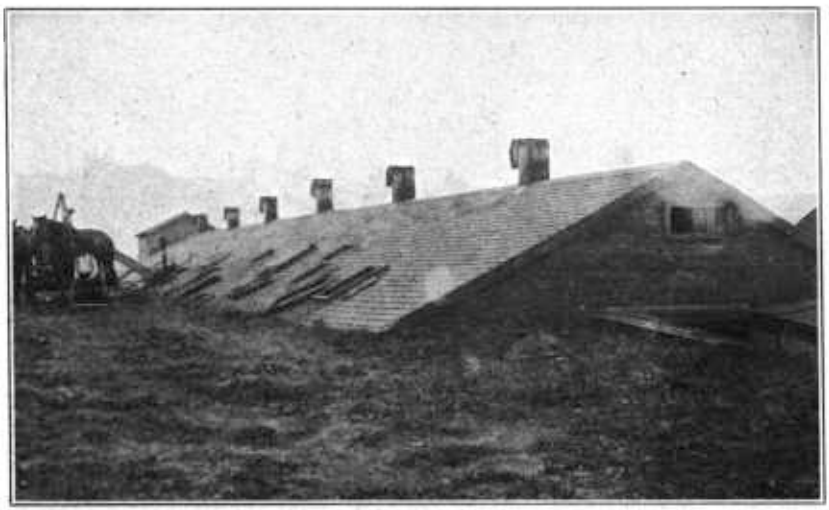


FIG. 21.—Hauling potatoes from the field to the storage house in untied sacks. Sabin, Minn.

For further information as to details of construction and other matters pertaining to storage houses, see Farmers' Bulletin 847.

The requirements for the successful storage of potatoes may be stated as follows:

(1) The tubers must be protected from extremes of cold and heat. A temperature ranging from 35° to 40° F. is considered satisfactory.

(2) Sufficient ventilation must be provided to remove foul air and excess moisture.

(3) The storage house must be so constructed as to make it possible to exclude the light, as the table quality of potatoes quickly deteriorates in the light.

(4) The tubers should be dry and reasonably free from dirt when put into storage. An excess of moisture or of soil increases the amount of heat generated in a newly stored pile of potatoes. The soil tends to close up the spaces between the tubers, thus cutting off air circulation and helping to retain heat that would otherwise escape.

(5) All diseased, badly cut, or bruised tubers should be removed from the crop before putting it into storage.

(6) It is not advisable to store potatoes at a greater depth than 5 or 6 feet, and the floor dimensions of the bin should not be greater than 12 by 12 feet

unless provided with a series of ventilating shafts for the escape of moisture and heat. Ventilated division walls and floors are also desirable.[8]

It is a common practice for commercial growers and shippers to store potatoes in bins to a depth of 10 to 15 feet. This is almost certain to entail a much heavier shrinkage loss than when stored at a depth of not more than 6 feet. The heavier shrinkage is the result of the greater degree of heat generated by a large pile of potatoes, which results in a higher moisture loss as well as a heavier loss from decay, as it is well known that heat and moisture are both conducive to the development of organisms causing tuber rots. Frequently the losses sustained when potatoes are stored under the conditions just mentioned may reach 25 per cent, and where care has not been exercised in rigidly removing all diseased tubers before storing the crop the loss may exceed that figure.

FIG. 22.—Grading or sizing potatoes in the field. Jerome, Idaho

Potatoes stored throughout the winter season under conditions meeting the requirements suggested above should not sustain an actual loss in storage of more than 5 per cent, and under exceptionally good conditions it may be as low as 3 or 4 per cent. Assuming that 5 per cent represents the average loss under good storage conditions and that 20 per cent would be a fair average allowance under poor conditions, the actual monetary loss sustained by the grower or dealer on 300,000 pounds of potatoes would in the one case be 15,000 pounds and in the other 60,000 pounds, or expressed in dollars on a basis of $1 per hundredweight a loss of $150 under good and of $600 under poor storage conditions. Besides this, there is an additional loss in storing potatoes to a depth of 10 to 15 feet which is not usually taken into consideration, and that is the mechanical injury through the cracking and bruising of the tubers at the bottom of the pile due to the great weight of the potatoes on top.

[8] Stuart, William. POTATO STORAGE AND STORAGE HOUSES. U. S. Dept. of Agr., Farmers' Bul. 847, 27 pp. 1917.

SUMMARY

(1) About 85 per cent of the potatoes of the United States are grown as a late or main crop.

(2) The potato is essentially a cool-loving plant; hence its production is confined very largely to the cooler portions of the world.

(3) Although the potato thrives best on sandy, gravelly, or clayey loam soils, it is probably as cosmopolitan in its soil requirements as any other agricultural plant.

(4) Potatoes are most successfully and economically produced on land on which a definite crop rotation is practiced. Leguminous crops, such as clover or alfalfa, are the best preparatory crops.

(5) Thorough preparation of the land is essential if a heavy crop is to be secured.

(6) The potato must have an abundant supply of available plant food in order to produce a maximum crop. Farm manures are valuable but are not well balanced; they give the best results when supplemented by an application of commercial fertilizer containing a relatively low percentage of nitrogen and potash and a high percentage of phosphorus.

(7) The Green Mountain and Rural varieties are the leading late or main-crop potatoes in the northeastern United States, and the Charles Downing (Idaho Rural) and Burbank varieties in the West.

(8) The date of planting should be governed by the character of the growing season. In northern regions, where the season is short, there is little, if any, choice left to the grower other than to plant as soon as it is considered safe from late spring frosts. Where the growing season is longer than is required for the complete maturity of the potato, planting should be delayed if by so doing the period of tuber formation can be deferred until after the passage of a hot, dry period.

(9) The use of good seed is necessary if large yields are to be obtained.

(10) A liberal use of seed is advisable. Seed pieces weighing 1¼ to 1½ or 2 ounces are preferable to smaller ones.

(11) Maximum yields can not be obtained if the rows are spaced too far apart or the distance between the plants in the row is too great.

(12) The two-man type of planter when properly operated insures a better stand than the picker type, but is somewhat more costly to operate.

(13) Whether the level or ridge system of culture is preferable is determined largely by climatic conditions. In irrigated regions ridging is necessary for the proper distribution of the water.

(14) Thorough cultivation of the potato crop is essential to a profitable yield.

(15) Spraying the growing plants is necessary for their proper protection from insect pests and fungous diseases.

(16) In the strictly potato-producing regions of the United States the crop is harvested with the elevator type of digger.

(17) There is considerable lack of uniformity in the areas of the United States producing late potatoes with respect to the packages or containers used in handling the crop.

(18) A good potato storage house is almost a necessity if maximum returns from the crop are to be obtained.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	HENRY A. WALLACE.
Assistant Secretary	REXFORD G. TUGWELL.
Director of Scientific Work	A. F. WOODS.
Director of Extension Work	C. W. WARBURTON.
Director of Personnel and Business Administration.	W. W. STOCKBERGER.
Director of Information	M. S. EISENHOWER.
Solicitor	SETH THOMAS.
Bureau of Agricultural Economics	NILS A. OLSEN, *Chief.*
Bureau of Agricultural Engineering	S. H. MCCRORY, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Biological Survey	PAUL G. REDINGTON, *Chief.*
Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Office of Cooperative Extension Work	C. B. SMITH, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Entomology	C. L. MARLATT, *Chief.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Chief.*
Forest Service	R. Y. STUART, *Chief.*
Grain Futures Administration	J. W. T. DUVEL, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*
Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Bureau of Plant Quarantine	LEE A. STRONG, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Weather Bureau	CHARLES F. MARVIN, *Chief.*

U. S. GOVERNMENT PRINTING OFFICE: 1933

For sale by the Superintendent of Documents, Washington, D. C. - - - - - Price 5 cents